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Issued September 8, 1914

United States Department of Agriculture,

BUREAU OF PLANT INDUSTRY,

Western Irrigation Agriculture,

WASHINGTON, D. C.

THE WORK OF THE BELLE FOURCHE RECLAMATION PROJECT EXPERIMENT FARM IN 1913.[1]

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INTRODUCTION.

The work of the Belle Fourche Experiment Farm consists of a number of field-crop experiments, both with and without irrigation. From 1907 to 1911 all the experiments were conducted on dry land. Irrigation water was first brought to the farm in 1912, when experiments under irrigation were commenced.[2] The work of the farm includes field tests with grains, forage crops, vegetables, orchard and shade trees, and a number of rotation and tillage experiments. The arrangement of the fields and the location of the experiments in 1913 are shown in figure 1.

COOPERATION.

Much of the experimental work is done in cooperation with other offices of the Bureau of Plant Industry and with the Forest Service. The nature and extent of this work is here indicated.

Biophysical Laboratory.—The Biophysical Laboratory cooperates in all climatological and physical observations. This work includes

[1] The Belle Fourche Experiment Farm consists of 280 acres of land on the Belle Fourche (S. Dak.) Reclamation Project, of which 160 acres were set aside by Executive order and 120 acres were withdrawn from entry by the Department of the Interior for use as an experiment farm. There are 240 acres under cultivation, 90 acres dry land and 150 acres irrigated. The farm is operated by the Bureau of Plant Industry of the United States Department of Agriculture and is in charge of the Office of Western Irrigation Agriculture. A farm superintendent, detailed by that office, has general supervision of the experiments.

[2] A report of the work of this farm in 1912 was published in Bureau of Plant Industry Circular 119, issued Mar. 29, 1913.

Note.—This circular contains an account of the progress made in 1913 in experiments with irrigated field crops and in some dry-land experiments at this farm. The chief points covered are: (1) Crop rotations, including experiments in pasturing hogs on alfalfa and corn in the rotations; (2) rate of seeding alfalfa; (3) time and method of seeding alfalfa; (4) the use of flax as a nurse crop for alfalfa; (5) the irrigation of alfalfa; (6) variety test of corn; (7) yield test of mangels; (8) fall irrigation of flax; (9) pasture-grass tests; (10) experiments in breaking native sod at different times; (11) experiments with trees; (12) experiments with vegetables. The circular is principally for distribution to the farmers of the Belle Fourche Reclamation Project in order that they may be informed as to the various experiments in progress at the farm and as to the methods of producing the different irrigated crops.

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measurements of rainfall, wind velocity, evaporation, temperature, and soil-moisture studies.

Dry-Land Agriculture.—The Office of Dry-Land Agriculture uses about 20 acres, divided into one-tenth-acre plats, for rotation and tillage experiments, above the canal. These experiments include continuous cropping by ordinary methods and moisture-conservation methods compared with alternate cropping and summer-fallowing, a comparison of various 3-year rotations, and crop rotations for

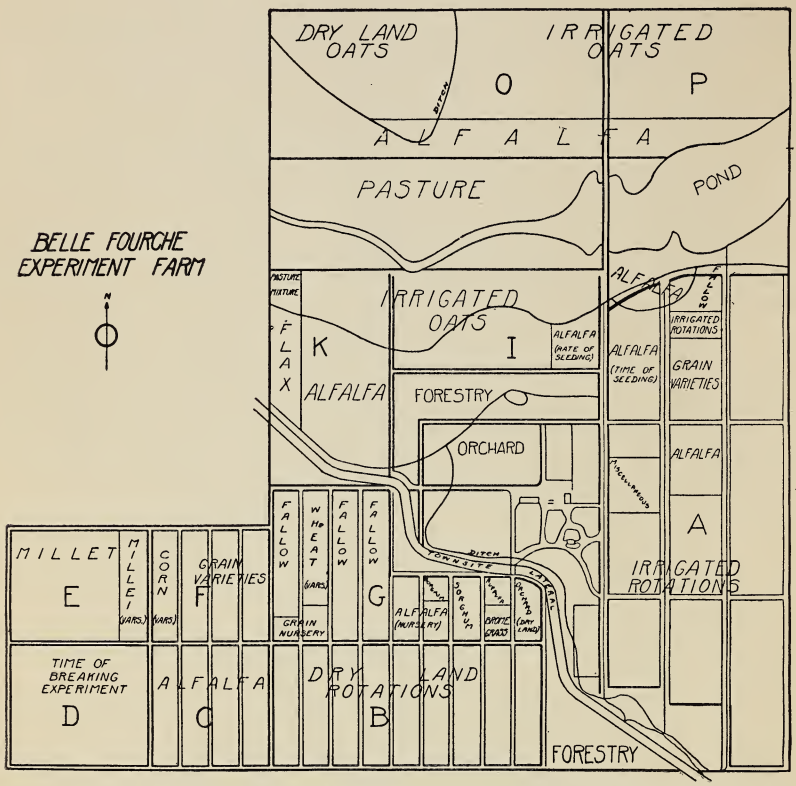

FIG. 1.—Diagram of the Belle Fourche Experiment Farm, showing the arrangement of the fields and the location of the crop experiments in 1913.

the conservation of humus. An assistant in dry-land agriculture is detailed to the farm to supervise this work.

Cereal Investigations.—This office has charge of the variety testing of grains suited to dry-land conditions and of plant-breeding work with the most promising varieties of grains. During the years 1912 and 1913 much time was devoted to investigations as to the best time and method of seeding winter wheat. An assistant detailed by the Office of Cereal Investigations has charge of these experiments. Approximately 20 acres of land are used.

Alkali and Drought Resistant Plant Investigations.—This office does variety testing and plant-breeding work with forage crops, including alfalfa, brome-grass, western wheat-grass, sorghum, and millet, and conducts studies of the water requirements of the different varieties and strains tested. About 15 acres of land are devoted to the work, and an assistant is detailed to supervise the experiments.

Corn Investigations and Sugar-Plant Investigations.—The Offices of Corn Investigations and Sugar-Plant Investigations cooperate in the work with corn and sugar beets, respectively, each office using about 2 acres of land. The tests with these crops include variety testing and tillage experiments.

Forest Service.—The United States Forest Service cooperates in the testing of trees for wood-lot and windbreak purposes. About 9 acres of land are used for this purpose.

CONDITIONS ON THE PROJECT.

CLIMATIC CONDITIONS.

The season of 1913 was rather less favorable to small-grain crops than the average season. This was due in part to the late spring, no field work being done until after April 15. While at that time there was sufficient moisture in the soil to bring up the grain, the later seedings came up very unevenly and some failed to germinate until after the rains which came the latter part of May, so that in many instances poor stands were obtained. The conditions were somewhat more favorable to alfalfa and corn, both of which produced higher yields than in 1912. On June 22 a hailstorm on the northern part of the project damaged all the crops to some extent, but no serious damage was done at the experiment farm. The rainfall up to July 1 was very nearly normal, while that in July, August, and the first half of September was very much less than the normal. The total for the year was 12.53 inches, which was slightly below the average for the past six years. The climatological observations made during the six years from 1908 to 1913, inclusive, are summarized in Table I.

TABLE I.—*Summary of climatological observations at the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

PRECIPITATION (INCHES).

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1908	0.20	0.19	1.65	1.16	3.95	1.47	1.26	0.62	0.52	2.03	0.20	0.91	14.16
1909	.17	.23	.19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	17.73
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.03	2.92	.27	.11	.10	12.25
1911	.13	.05	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	12.53
Average	.34	.25	.76	1.05	2.28	2.08	1.58	1.19	1.88	.97	.36	.53	13.28

TABLE I.—*Summary of climatological observations at the Belle Fourche Experiment Farm, 1908 to 1913, inclusive*—Continued.

EVAPORATION (INCHES).

Year, etc.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1908				5.53	5.92	6.82	8.08	7.87	6.75				40.97
1909				3.65	6.42	5.86	7.70	8.25	5.00				36.88
1910				5.41	5.31	8.98	10.42	7.30	4.31				41.73
1911				4.65	8.30	10.24	10.71	6.68	6.11				46.69
1912				4.85	6.42	8.18	7.92	6.60	3.71				37.74
1913				4.71	4.30	7.05	8.24	8.14	4.71				37.15
Average				4.80	6.11	7.85	8.85	7.47	5.10				40.19

DAILY WIND VELOCITY (MILES PER HOUR).

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Mean:													
1908					8.3	7.2	5.0	6.8	6.5				
1909				9.1	10.1	6.2	6.0	5.6	5.7	6.3	5.5		
1910			6.3	9.2	8.2	9.3	7.7	6.6	6.2	7.1	6.5	9.2	
1911	7.5	5.8	9.6	9.2	11.6	9.1	7.9	7.2	7.7		10.0	7.6	
1912	6.9	7.3	6.6	9.5	11.1	7.6	6.0	6.9	7.6				
1913				6.2	5.9	6.8	5.8	5.1	4.5				
Maximum:													
1908					19.6	12.1	12.9	9.0	13.8				
1909				26.8	21.7	12.9	11.6	11.8	9.8	13.8	15.0		
1910			18.9	23.8	22.0	19.4	17.6	17.6	12.1	18.3	16.7	28.0	
1911	18.8	11.4	19.6	18.6	19.4	20.7	19.4	15.2	15.9		21.7	15.0	
1912	17.5	16.7	18.8	24.9	25.3	17.5	10.0	12.4	26.3				
1913				16.5	12.4	18.9	14.4	9.0	13.8				
Minimum:													
1908					2.1	1.7	1.7	2.5	2.9				
1909				2.5	2.6	2.9	2.5	2.5	2.5	2.1	.9		
1910			1.7	3.1	1.6	3.1	3.0	2.9	2.2	2.5	2.5	1.8	
1911	1.2	.8	2.4	3.3	3.9	4.5	2.8	2.6	2.5		1.3	2.1	
1912	.8	2.1	1.8	3.0	2.9	2.8	3.0	2.1	1.5				
1913				1.3	1.2	2.4	1.7	1.9	.9				

MONTHLY TEMPERATURE (°F.).

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Mean:													
1908				48	52	63	73	68	64	45	37	22	
1909	12	23	32	38	52	66	70	75	61	46	21	10	
1910	18	8	46	51	52	68	76	68	59	51	31	25	
1911	20	22	39	42	58	73	71	65	59	43	25	20	
1912	12	25	19	47	55	66	70	68	52	45	38	28	
1913	13	17	23	48	53	66	70	74	59	42	37	23	
Maximum:													
1908				89	79	90	100	101	105	82	75	49	
1909	50	51	65	73	84	95	100	105	96	84	73	49	
1910	45	46	87	89	81	108	109	101	97	91	67	52	
1911	59	61	78	88	90	101	105	100	94	82	58	51	
1912	44	49	70	78	84	101	94	95	94	85	70	57	
1913	48	62	54	89	95	98	101	104	97	80	64	51	
Minimum:													
1908				5	29	39	43	39	22	22	0	—12	
1909	—24	—19	12	6	22	45	41	45	31	11	— 7	—23	
1910	—19	—26	22	24	27	36	44	32	30	13	8	—13	
1911	—22	— 7	8	7	23	43	41	32	35	— 1	— 8	—25	
1912	—32	—12	—15	22	32	39	40	47	24	22	11	2	
1913	—32	—14	—20	24	26	45	42	45	29	14	14	— 1	

KILLING FROSTS.

Season.	1908	1909	1910	1911	1912	1913	6-year average.
Last spring frost	May 21	May 18	May 21	May 12	May 4	May 6	
First fall frost	Sept. 22	Sept. 24	Sept. 26	Oct. 4	Sept. 25	Sept. 24	
Frost-free period.....days..	128	128	127	146	144	141	136

CROP CONDITIONS.

The area of land devoted to field crops on the Belle Fourche project in 1913 was larger by about 8,000 acres than in 1912, an increase of about 32 per cent. The total irrigated area of the 581 farms on the project in 1913 was 32,851 acres. Of this an area of 313 acres was devoted to young alfalfa and miscellaneous crops not harvested, so that the area from which crops were harvested contained 32,568 acres. The area devoted to alfalfa in 1913 amounted to about 9,000 acres, which is 2¼ times as large as the area from which alfalfa was harvested in 1912. In 1913 corn and small grains were grown on about 21,000 acres, or about 64 per cent of the total cropped area of the project. The acreage, yields, and farm values of the crops produced on the project in 1913 are stated in Table II, the figures being obtained from the United States Reclamation Service.

TABLE II.—*Acreage, yields, and farm values of crops on the Belle Fourche project in 1913.*

Crop.	Area (acres).	Unit of yield.	Yield.			Farm value.			
			Total.	Per acre.		Per unit of yield.	Total.	Per acre.	
				Average.	Maximum.			Average.	Maximum.
Alfalfa hay	7,388	Ton	15,854	2.1	5.0	$4.50	$71,343	$9.65	$22.50
Alfalfa seed	1,576	Bushel	2,157	1.4	4.5	6.00	12,492	8.21	27.00
Barley	744	do	18,101	24.3	76.5	.60	10,861	14.59	45.90
Beans	67	do	447	6.7	40.0	2.00	894	13.34	80.00
Sugar beets	8	Ton	47	5.9	12.0	5.00	235	29.37	60.00
Corn	1,859	Bushel	35,615	19.1	60.0	.80	28,492	15.32	48.00
Corn fodder	709	Ton	729	1.0	4.0	4.00	2,916	4.11	16.00
Flax	219	Bushel	1,027	4.7	19.0	1.50	1,540	7.03	28.50
Garden	177						3,820	21.58	
Native hay	2,533	Ton	2,232	.9	2.0	10.00	22,320	8.81	20.00
Millet seed	54	Bushel	315	5.8	27.0	1.00	315	5.83	27.00
Oats	5,343	do	161,765	30.3	74.5	.40	64,706	12.11	29.80
Pasture	285						1,990	6.98	
Potatoes	298	Bushel	25,704	86.3	400.0	.60	15,422	51.75	240.00
Rye	71	do	768	10.8	20.0	.60	461	6.49	12.00
Wheat	13,096	do	195,205	14.9	35.0	.60	117,123	8.94	21.00
Less duplications	1,859								
Total	32,568						355,380		
Average								10.91	

EXPERIMENTS WITH IRRIGATED CROPS.

CROP ROTATIONS.

In the spring of 1912 a series of 32 rotation experiments under irrigation was commenced. Field A, which is used for these experiments, contains 88 quarter-acre plats. A portion of this field is shown in figure 2. The following crops are grown in various sequences: Alfalfa, sugar beets, clover, flax, oats, wheat, barley, corn, and potatoes. Each of these crops is also grown continuously on the same plat each year for the purpose of comparing continuous cropping with crop rotation. The rotation experiments include eleven 2-year

rotations, four 4-year rotations, three 3-year rotations, and six 6-year rotations. Table III gives the number of plats devoted to each crop in these experiments and the minimum, maximum, and average yields obtained in 1913.

TABLE III.— *Yields per acre of crops grown in the irrigation rotation experiments at the Belle Fourche Experiment Farm in 1913.*

Number of plats.	Crop.	Yield per acre.		
		Minimum.	Maximum.	Average.
15	Sugar beets.....tons..	4.7	10.7	7.8
18	Oats.....bushels..	24.1	54.5	39.0
2	Barley.....do....	14	14.8	14.4
5	Wheat.....do....	13.7	31.3	19.9
13	Potatoes.....do....	74	176	112.5
6	Corn.....do....	21.6	43	34
3	Flax.....do....	6.1	18.6	13.4
12	Alfalfa.....tons..	.75	5.3	2.6

FIG. 2.—A view in field A, where the irrigated crop-rotation experiments are in progress. Thirty-two different cropping systems are being tested.

The seed used in the first planting of beets, made on May 1, failed to make a satisfactory stand, and the plats were all replanted on June 17. A good stand was secured from the second planting, but the lateness of this planting probably reduced the yield considerably. The average yield per acre of the beets was only 0.17 ton higher than in 1912, but the percentage of sugar and the purity were very much higher. The average sugar content was 19.1 per cent in 1913, as compared with 14.8 per cent in 1912, and the average purity was 91.2 per cent, as compared with 82 per cent the year before. In 1913 the best yield of beets was obtained on land which produced potatoes

in 1912. The lowest yield in 1913 was obtained where beets followed beets.

The best yield obtained from the 18 plats of oats was from land which produced potatoes in 1912, and the lowest yield was obtained from the plat which had been continuously cropped to oats. The average yield of oats was 39 bushels per acre in 1913, as compared with 51.9 bushels per acre in 1912.

The highest wheat yield obtained in 1913, 31.3 bushels per acre, was obtained on land which produced beets in 1912, and the lowest yield was secured from the continuously cropped wheat plat.

The yield of potatoes was probably reduced by a frost which occurred on September 24, when the vines were still green. The average yield was only 112.5 bushels per acre. The highest yield was obtained on alfalfa land, which produced 176 bushels per acre.

The average yield of corn was 34 bushels per acre, which was 5 bushels more than the yield obtained in 1912. The highest yield was obtained where corn followed barley.

The three plats of flax averaged 13.4 bushels per acre, practically the same as in 1912. The best yield was obtained from land which produced beets in 1912, and the lowest yield was secured from the plat which has been continuously cropped to flax. From the observations made in 1913 it appears that the flax should be kept in good growing condition up to the time of full bloom and that no irrigation water should be applied after that time. Late irrigation appears to prevent the flax from ripening evenly, and it starts new branches from the lower joints. This causes some difficulty both in harvesting and thrashing and also lowers the quality of the seed. The highest yield of alfalfa seeded in the spring of 1913 was 2.3 tons per acre, and the lowest 0.75 ton. The average yield of all the first-year plats was 1.31 tons per acre. The highest yield per acre obtained from the alfalfa planted in 1912 was 5.36 tons, the lowest was 2.86 tons, and the average of all the plats was 3.49 tons.

PASTURING ALFALFA WITH HOGS.

In rotation 65, a 6-year rotation of corn, flax, oats, and three years of alfalfa, hogs were pastured on the second-year alfalfa. The plan of the experiment contemplates that the hogs will be pastured on third-year alfalfa, but as the experiment was not started until 1912 it was necessary to pasture second-year alfalfa in 1913. On May 20, 1913, three hogs, averaging 153 pounds each, were turned on the quarter-acre plat. A ration of 2 pounds of equal parts of ground wheat, oats, and barley per day for each 100 pounds of live weight was used as a supplementary feed. The hogs were left on the plat for 39 days, when it was found necessary to remove them to allow the alfalfa to grow up. On July 2 the hogs were again placed in

the pasture. It was found that the alfalfa was soon overgrazed, and the hogs were removed on August 6, after being on the plat for 35 days. During the two periods, 74 days, the hogs gained 171 pounds. In making this gain they consumed 738 pounds of ground feed, which, at $1.25 a hundred, was worth $9.22. The 171 pounds of gain, at the local market price of 7 cents, was worth $11.97, so that the net value of the gain from the alfalfa was $2.75 on one-fourth acre, or $11 an acre.

It was thought that better results would be obtained if younger hogs were used and if the plat was divided so that half the land would be pastured while the alfalfa was growing on the other half. Accordingly, the plat was subdivided on August 7, and eight hogs, averaging 39 pounds each, were turned into the alfalfa. They were pastured alternately on the two subdivisions of the plat for 20 days. During this time they were fed 335 pounds of the ground feed, which, at $1.25 a hundred, was worth $4.19. The hogs gained 96 pounds in the 20 days. This gain, at 7 cents a pound, was worth $6.72. The net gain, then, from the quarter acre of alfalfa for the 20 days was $2.53, or $10.12 an acre. The younger hogs on the subdivided plat netted practically as much in 20 days as the larger hogs on the same plat not subdivided netted in 74 days. There can be no doubt as to the desirability of using relatively young hogs and of subdividing the land to be pastured if the alfalfa is to be used to the best advantage.

While the results obtained in this work in 1913 were not as good as might be expected, they indicate that to use the alfalfa land for hog pasture can be made a very profitable method of disposing of the alfalfa crop. The net value of the gains made by the hogs in this experiment was $21.12 per acre for the entire season. The average yield of alfalfa on 13 quarter-acre plats in the same field in 1913 was 3.5 tons per acre. Assuming that the pastured plat would have yielded at this rate, the value of the gain made by the hogs was equivalent to $6.03 per ton for the alfalfa consumed. The average yield of the third crop was 1.14 tons per acre. The young hogs which were pastured during a part of the growing period of the third crop made a net gain of $10.12 per acre, which was equivalent to about $9 a ton for the alfalfa consumed. During the season the market price of alfalfa hay on the project was about $5 a ton.

HOGGING CORN.

The corn plat in rotation 65 is to be harvested by hogs each year. In 1913 the eight young hogs used in the alfalfa pasturing experiment were turned into the corn plat on September 15. At the time the hogs were put on the corn plat they averaged 51 pounds each. They were left in the corn for 11 days, during which time they consumed all of the crop. During this period they gained 140 pounds from the

quarter acre of corn, or 560 pounds per acre. This gain, at the local market price of 7 cents per pound, was worth $39.20 an acre. The average yield of corn on the six other plats in the same field was 34.04 bushels per acre. Assuming that the hogged plat produced at the average rate, the gain made by the hogs was worth $1.13 a bushel for the corn consumed. The market price of corn on the project was 80 cents a bushel.

In 1912, hogs pastured on corn in the same experiment made a net gain worth $27.20 an acre. The average yield of corn in the rotation field in 1912 was 29.9 bushels per acre, so that the gains made by the hogs were equivalent to 91 cents a bushel for the corn consumed if it is assumed that the hogged plat produced an average yield.

The results secured in 1912 and 1913 indicate that hogging is one of the most profitable methods of disposing of the corn crop. It should be remembered that the figures given do not include the cost of harvesting the corn by the usual methods and that this amount should be added to the figures giving the net returns per acre. The fact that the manure from the hogs is left on the land when the corn is hogged is another important point to be considered.

RATE OF SEEDING ALFALFA.

An experiment to determine the most satisfactory rate at which to seed alfalfa was started in 1913 on land that was summer-fallowed during the season of 1912. The alfalfa was seeded June 5 with a disk drill. The crop was clipped once during the year, but there was not enough plant growth to determine hay yields. Table IV shows the rates of seeding and the stand obtained from each rate and also the percentage of seeds producing plants. The figures in the last column are based on the assumption that a pound of alfalfa seed contains 225,000 seeds.

TABLE IV.—*Stands secured and percentage of seeds producing plants in rate-of-seeding tests with alfalfa at the Belle Fourche Experiment Farm in 1913.*

Plat No.	Rate of seeding per acre.	Stand (plants per acre).	Percentage of seeds producing plants.
	Pounds.		
1	2.5	102,000	18
2	3.0	73,000	11
3	4.5	97,000	10
4	6.0	114,000	8
5	8.0	139,000	8
6	10.0	135,000	6
7	11.5	126,000	5
8	13.0	143,000	5
9	15.0	156,000	5
10	16.5	175,000	5
11	18.5	202,000	5
12	20.5	210,000	5
13	22.5	227,000	4
14	25.0	194,000	3
Average	12.6	149,000	7

The final results of this experiment will not be obtained until several crops of hay have been harvested. From the results obtained in 1913 it appears that rates varying from 8 to 15 pounds per acre are sufficiently high, so far as satisfactory stands are concerned, but additional results must be secured before the relative desirability of the different rates can be determined.

TIME AND METHOD OF SEEDING ALFALFA.

Alfalfa can be seeded on the Belle Fourche project at any time from early spring until midsummer, but the most convenient time is just before planting potatoes, corn, and sugar beets, or else about one month later, after these intertilled crops are planted. An experiment was started in 1913 on field A–III to determine which of these two planting periods is the better. The plantings were made on quarter-acre plats. On some of the plats alfalfa was planted with a nurse crop of wheat to determine whether that method is desirable. The four plats planted with a nurse crop are compared with those in which alfalfa was planted alone. On two plats the nurse crop was cut for hay, while on the other two the wheat was harvested for the grain. On three plats the alfalfa was planted in rows 21 inches apart and cultivated. The chief reason for planting in rows was to experiment with this method of alfalfa-seed production. The yields obtained in this experiment in 1913 are given in Table V.

TABLE V.— *Yields obtained from different times and methods of seeding alfalfa at the Belle Fourche Experiment Farm in 1913.*

Method and time of seeding.	Number of plats.	Average yield per acre.				
		Alfalfa.			Wheat hay.	Wheat.
		First crop.	Second crop.	Total.		
		Tons.	*Tons.*	*Tons.*	*Tons.*	*Bushels.*
Without nurse crop, May 9 (early)	3	0.78	0.31	1.09	.....	.....
Without nurse crop, June 5 (late)	3	.50	.21	.71	.....	.....
With nurse crop, May 9, cut for hay	2	.....	.....	.....	1.42	.....
With nurse crop, May 9, cut for grain	2	.....	.....	.....	.....	28.2
In 21-inch rows, June 5	3	.31	.18	.49	.....	.....

It is seen that the early-seeded alfalfa yielded somewhat more than that seeded late. Assuming that the price of wheat hay is the same as that of alfalfa hay, about $5 a ton, planting with a nurse crop and harvesting the wheat as hay gave larger returns per acre than planting the alfalfa alone. When the cost of harvesting and thrashing the wheat for grain is considered, it is seen that this method is less profitable than either of the two methods previously mentioned, for the yield of 28.2 bushels per acre is little more than sufficient to pay

the cost of production on irrigated land. The returns for the row plantings were the smallest obtained in the experiment. It should be remembered that these statements apply to the first year's results only. The final effect of time and method of seeding can not be known until the alfalfa yields to be obtained from the different methods have been determined for two or three years. The stands of alfalfa obtained appear to be practically the same in all cases, except, of course, when the alfalfa was planted in rows.

THE USE OF FLAX AS A NURSE CROP FOR ALFALFA.

An experiment to determine the value of flax as a nurse crop for alfalfa was started in 1913 on field K. One acre was seeded to alfalfa at the rate of 10 pounds per acre, with flax seeded at the rate of 42 pounds per acre as a nurse crop. About 5.5 acres of land adjoining this was seeded to alfalfa alone, at the rate of 10 pounds per acre. The seeding was done on May 7. Shortly after seeding, a heavy rain packed and crusted the soil in this field. The flax, germinating much more promptly than the alfalfa, appeared to break the crust and to give the alfalfa a better chance to come through. The alfalfa seeded alone yielded at the rate of 0.5 ton per acre. No hay yield was obtained from the field where flax was used as a nurse crop, but the flax produced 8.4 bushels of seed per acre. A good stand was obtained by both methods, but the alfalfa appeared to be slightly thicker where flax was used as a nurse crop. Counts made on representative areas in the fall of 1913 indicated that where the alfalfa was planted alone there were 146,000 plants per acre as compared with a stand of 151,000 plants where the flax was used as a nurse crop. Considering the cost of culture during the year, the net value of the crop obtained where flax was used as a nurse crop was slightly higher than that of the alfalfa planted alone. The results secured in 1913 indicate that the use of flax as a nurse crop may prove to be a profitable practice.

IRRIGATION OF ALFALFA.

An experiment was conducted in 1913 to determine the effect of the late-fall irrigation and the early-spring irrigation of alfalfa as compared with irrigating in the usual way. The experiment was conducted on five quarter-acre plats in field A. Two plats were irrigated in the fall of 1912, one was irrigated early in the spring of 1913, and two were irrigated in the usual way, the first irrigation having been applied June 5, 1913. The plats irrigated late in the fall of 1912 and the plat irrigated early in the spring of 1913 were otherwise irrigated in the usual way. The precipitation during the fall of 1912 and the winter of 1912–13 was unusually heavy and the

soil on all the plats contained an abundance of moisture, so that little effect was produced by irrigation in the fall and early spring. The yields of alfalfa hay from the different plats indicated no important effect of late-fall or early-spring irrigation. It is probable that in seasons having a light fall and winter precipitation fall irrigation or early-spring irrigation would have a beneficial effect. Whether or not this will be the case remains to be determined.

VARIETY TEST OF CORN.

In 1913 nine varieties of corn were tested, both on dry land and under irrigation. The varieties all failed to produce a crop of grain on the dry land. The yields obtained on irrigated land are shown in Table VI, being calculated on a basis of 12 per cent moisture. The varieties were planted in duplicate plats two rows wide and 110 feet long, the work being done in cooperation with the Office of Corn Investigations.

TABLE VI.—*Average yields of nine varieties of corn at the Belle Fourche Experiment Farm, 1913.*

Variety.	Date of maturity.	Yield per acre.	Variety.	Date of maturity.	Yield per acre.
		Bushels.			*Bushels.*
Marten's White Dent	Sept. 11	60.4	Brown County Yellow	Sept. 6	51.2
Northwestern Dent	Sept. 4	56.2	Ardmore Yellow Dent	do	49.2
U. S. Selection 133	Sept. 13	56.2	Disco Flint	Sept. 13	45.5
Payne's White Dent	Sept. 11	55.3	Minnesota No. 23	Sept. 6	38.6
Disco Dent	Sept. 15	45.5	Average		51.8

The highest yield was produced by Marten's White Dent, which averaged 60.4 bushels per acre. The lowest yield was produced by Minnesota No. 23, which yielded 38.6 bushels per acre. The average yield of all the varieties was 51.8 bushels per acre. Northwestern Dent, the second best yielder, was the earliest in maturity, but the differences in time of maturity of the different varieties were not great.

MANGELS.

The increasing interest in dairy farming on the project makes it desirable that satisfactory forage crops be found for use in supplementing alfalfa in the rations fed to milk cows. Mangels are generally considered one of the best supplementary feeds for this class of stock. In order to determine how mangels would behave under the conditions on the project, a quarter-acre plat (fig. 3) in field A was planted in rows 21 inches apart, and when the plants came up they were thinned to 10 inches within the row. The crop was irrigated three times and harvested on October 25. A yield of 26 tons per acre was secured.

FALL IRRIGATION OF FLAX.

An experiment was conducted in 1913 on two quarter-acre plats in field A to determine the effect of fall irrigation of land to be planted to flax. One plat was heavily irrigated on November 8, 1912, and the other was not irrigated in the fall. During 1913 flax was grown on both plats and given the same treatment throughout the season. The fall-irrigated plat yielded at the rate of 18 bushels per acre and the other plat produced 18.6 bushels per acre. The absence of any effect on the yield of the fall-irrigated plat was probably due to the unusually heavy rainfall in the autumn of 1912, as previously mentioned. This experiment has been enlarged and will be continued in 1914.

PASTURE-GRASS MIXTURES.

In order to determine the feasibility of pasturing on the irrigated lands of the project, a test of pasture-grass mixtures was started on

FIG. 3.—A plat of mangels at the Belle Fourche Experiment Farm in 1913 which yielded at the rate of 26 tons per acre. Mangels promise to be a valuable crop for dairy farmers on the project.

field K in 1913. The seed used was furnished by the Office of Forage-Crop Investigations. Three different mixtures were planted on three quarter-acre plats. These mixtures, which were planted on May 24, contained the seed of the grasses and legumes mentioned below and were planted at the rates specified in pounds per acre.

Mixture A.—This mixture contained timothy, 4 pounds; redtop, 4 pounds; Kentucky bluegrass, 4 pounds; orchard grass, 6 pounds; awnless brome-grass (*Bromus inermis*) 2 pounds; meadow fescue, 2 pounds; tall fescue, 2 pounds; Italian rye-grass, 2 pounds; western wheat-grass, 6 pounds; and perennial rye-grass, 2 pounds.

Mixture B.—Mixture B was the same as mixture A, except that 2 pounds of white clover and 2 pounds of alsike clover seed were added.

Mixture C.—The same grasses and legumes were included in mixture C as in mixture B and 2 pounds of alfalfa seed were added.

These pasture-grass mixtures were planted on land that was summer-fallowed in 1912. The land was disked and harrowed in the spring and kept free from weeds previous to planting. A disk drill was used in planting, but there was some difficulty in getting the drill to sow evenly, as the seed was so coarse and light that it would not readily fall into the seed cups. For several weeks after planting it looked very doubtful whether a stand would be secured, but after the first irrigation, on July 19, the plants came up rapidly and the stand continued to improve until the end of the growing season, at which time there was a good stand on all three plats. It was found desirable to irrigate as frequently as every 10 days during the hottest weather, in order to keep the plants growing continuously. The crop was clipped once during the season, but there was not enough plant growth to determine yields. It is expected that these plats will be pastured in the summer of 1914 to determine whether it is practicable to pasture stock on these irrigated lands and to find out which of the mixtures gives the best results.

TIME-OF-BREAKING EXPERIMENTS.

An experiment was started in 1911 to determine the effect on dry-land grain yields of breaking sod land at different times of the year. This work was done on field D, which is not irrigated. A quarter-acre plat was plowed each month from April to October, inclusive, in 1911 and 1912, and one plat was plowed in April, 1913. The plat plowed on April 1, 1911, was replowed, or backset, in the fall of 1911, and the one plowed April 1, 1912, was replowed in the fall of 1912. In 1912 the eight plats plowed in 1911 were planted to Sixty-Day oats, but because of the severe drought of 1912 no crop was produced and the plats were all plowed in the fall. In the spring of 1913 these eight plats, and also eight plats which were plowed from April to October, 1912, and one plat which was plowed on April 15, 1913, were all seeded to Sixty-Day oats. Plat 9, which was plowed April 1, 1912, was backset in the fall of that year. Between the time of plowing and that of planting, all plats were kept free from weeds by shallow cultivation with a disk and a harrow. The yields obtained in 1913 are given in Table VII.

TABLE VII.— *Yields of Sixty-Day oats in the time-of-breaking experiment at the Belle Fourche Experiment Farm in 1913.*

Plat No.	Time of breaking.	Yield per acre.		Plat No.	Time of breaking.	Yield per acre.	
		Grain.	Straw.			Grain.	Straw.
	1911.	*Bushels.*	*Pounds.*		1912.	*Bushels.*	*Pounds.*
1	Apr. 1	10.1	448	9	Apr. 1	5.9	360
2	May 1	6.9	344	10	May 1	6.0	336
3	June 1	5.3	236	11	June 1	6.1	304
4	July 1	3.8	204	12	July 1	4.8	240
5	Aug. 1	7.6	260	13	Aug. 1	3.9	116
6	Sept. 1	5.5	192	14	Sept. 1	4.3	176
7	Oct. 1	5.2	208	15	Oct. 1	3.8	144
	1912.				1913.		
8	Apr. 1	(1)	(1)	16	Apr. 15	.9	28

[1] The records of this plat have been lost.

The land on which this experiment was located is fairly uniform but of poor quality, the shale coming very close to the surface. Owing to extremely dry conditions in July, the crop of 1913 was very nearly a failure on all the plats. There was a slight increase in yield, however, on the backset plats and on the plats plowed in the early summer. The chief indication of the results obtained is that it is not a desirable practice to plant oats on land during the same spring in which the land is broken. The experiment will be continued in 1914 on plats broken during the season of 1913.

TREE PLANTING.

Tests of various kinds of trees for shade, ornamental, and windbreak purposes have been carried on in cooperation with the Forest Service since 1909. During the first three years all the work was done on land above the canal, but in 1912 some plantings were made on irrigated land.

Dry land.—In the spring of 1909 about 3 acres of dry land were planted to the following trees: Cottonwood, white and golden willow, black locust, honey locust, green ash, Siberian pea, Russian white olive, Scotch pine, Black Hills spruce, and red cedar. The spring of 1909 was very favorable, and all the trees made a good growth during the year. They came through the winter of 1909 and 1910 without any winterkilling except the black locust and the Scotch pine. The black locust killed back rather badly and most of the Scotch pine killed out entirely.

In the spring of 1910, Austrian pine and hackberry trees were added to the plantings. The Austrian pine was a total failure, but about half a stand of hackberry was obtained. The season of 1910 was extremely dry, but all the trees which started growth in the spring made a good growth during the season, except the willows,

which suffered considerably from drought. During the winter of 1910–11 there was no winterkilling of any of the species. The summer of 1911 was the driest on record, the rainfall for the year being only 6.64 inches. The trees made but little growth during the summer, but none of the varieties was killed by the drought. They all passed successfully through the winter of 1911–12. All the trees made a good growth during the summer of 1912. There was an abundance of rain in the latter part of the summer and early fall, so the season's growth did not ripen up well to go into the winter. During the winter of 1912–13 the cottonwood and black locust were killed to the ground and nearly all the other varieties were killed back to some extent. The only varieties that came through without any winterkilling were the green ash, Siberian pea, honey locust, and red cedar. Of these species the green ash and Siberian pea are the most hardy and desirable. While both of these are slow growing, the fact that they withstand the severe conditions of drought and cold on the western plains makes them valuable.

It has been found at the experiment farm that to grow trees successfully the land must be thoroughly cultivated until the trees shade the ground enough to keep out the weeds and native grasses. It is best to use 1-year-old or 2-year-old stocks, as small trees are much more readily started than larger ones. While the trees are small, it is desirable to have them rather close together, as it is then much easier to keep them free from weeds. The trees at the experiment farm were planted 4 feet apart in rows 6 feet apart. After the second year, thinning should begin and continue as the trees require more space.

Irrigated land.—About 7 acres of land are used for testing trees under irrigation. The following are included in the plantings made in 1912 and 1913: Cottonwood, white elm, green ash, Siberian pea, Russian white olive, white willow, white elm, bull pine, and jack pine. Of these, the cottonwood, white elm, white willow, and green ash were planted in the spring of 1912. A good stand of green ash and white elm was secured, but a very poor stand of cottonwood was obtained, because of the poor condition of the trees when they were received. During the winter of 1912–13 the white elm and cottonwood killed back very badly, but they made a vigorous growth in 1913.

The remainder of the species mentioned were planted in the spring of 1913. Good stands were secured except in the case of the replanted cottonwoods. The work with trees under irrigation has not progressed far enough to warrant any specific recommendations as to which species should be planted by farmers on the project.

SOIL-DYNAMITING EXPERIMENT.

In order to determine the effect of dynamiting on the soil, an experiment was started in the fall of 1912 on three tenth-acre plats in field B, which lies above the canal. Plat B–VIII–1, was dynamited as described below, and the two other plats, which lie one on each side of plat B–VIII–1, were used as checks. The dynamited plat produced oats in 1910, was fallow in 1911, and produced millet in 1912; and plat B–VII–1, one of the check plats, was treated in the same way in 1910, 1911, and 1912. The other check plat, B–IX–1, was manured in the fall of 1910 at the rate of 20 tons per acre, and produced oats in 1911 and 1912. All three plats were plowed September 20, 1912.

On October 22, 1912, plat B–VIII–1 was dynamited. Dynamite of 20 per cent strength was used, the shots being placed 20 feet apart, 8 holes to a plat. The holes were 3 feet deep, and one-half pound of dynamite was used for each shot. The cost of this operation including dynamite, fuse, caps, and labor, was $12 per acre. In the spring of 1913 all three plats were given uniform treatment and seeded to Sixty-Day oats.

The dynamited plat yielded 18.4 bushels per acre, and the two check plats yielded 25.9 and 24.1 bushels per acre, respectively. The average of all the dry-land oat plats in field B was 23.9 bushels per acre. The crop conditions were favorable up to July 1, but after that all the dry-land crops suffered from drought.

While this one year's results do not warrant a statement that dynamiting is detrimental, it is important to state that the results obtained on the dynamited plat were similar to those usually obtained in dry years at the experiment farm on land which is deep tilled, particularly where subsoiling is practiced. In 1914 the three plats used in the dynamiting experiment will be planted again to the same crop, to see what the effect of dynamiting will be two years after the operation.

GARDEN VEGETABLES.

In 1912 and 1913, a number of different varieties of garden vegetables were grown under irrigation at the experiment farm. The list given below contains the names of the varieties which have given satisfactory results. A view of a part of the vegetable garden as it appeared in August, 1913, is shown in figure 4.

Cabbage.—Disco Eureka and Premium Flat Dutch. The first named is the earlier maturing.

Cauliflower.—Dwarf Erfurt and Early Snowball. The first named is preferred.

Pumpkin.—Small Sugar, Japanese Pie, and Connecticut Field. The last named is rather late in maturing.

Sweet corn.—Peep o' Day, Black Mexican, and Disco Evergreen.

Watermelon.—Sweet Heart, Cole's Early, and Fordhook Early.

Muskmelon.—Emerald Gem, Rocky Ford, and Disco Gem.

Cucumber.—Arlington White Spine and Improved Long Green.

Squash.—Yellow Summer Crookneck, Golden Hubbard, Mammoth, and Delicious.

Tomato.—Acme, Ponderosa, and Earliana.

Bean.—Early Red Valentine, Detroit Wax, Wardwell's Kidney Wax, and Seibert's Pole Lima.

Turnip.—Extra Early Milan and Purple Top Strap Leaf.

Pea.—Stratagem and Thomas Laxton.

FIG. 4.—View in the vegetable garden at the Belle Fourche Experiment Farm in 1913. Eighteen different kinds of vegetables have been successfully grown here.

Beet.—Crosby's Early, Detroit Dark Red, and Edmand's Blood Turnip.

Radish.—Early Scarlet Globe, Early Scarlet Turnip, and French Breakfast.

Lettuce.—Grand Rapids, May King, and Prize Head.

Onion.—Yellow Globe Danvers and Large Red Globe.

Parsnip.—Hollow Crown and Guernsey.

Carrot.—Oxheart, Danvers Half Long, and Chantenay.

FUTURE WORK.

Practically all the work conducted at the experiment farm in 1913 will be continued in 1914, and several new experiments will be started. Among the tests recently inaugurated are extensive experiments in

fall irrigation with oats, beets, flax, potatoes, barley, corn, and wheat; an experiment to determine the most satisfactory rate of planting for corn; and a variety test with potatoes. As rapidly as results are secured they will be published for the benefit of the farmers on the project.

Approved:
WM. A. TAYLOR,
Chief of Bureau.

JUNE 6, 1914.

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